Lessons Learned Entry 2977 Space Shuttle Propulsion Systems Ground Processing Lessons Learned

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- Shuttle Ground Operations Efficiencies Technologies Study (SGOE/T)
  - Determine why it takes so long and cost so much
  - What are the major time and cost drivers
  - Need to improve Operability and Maintainability
- Lessons learned: A Major Cost Driver was Propulsion Systems
  - Study was initiated: **OPERATIONALLY EFFICIENT PROPULSION SYSTEM STUDY (OEPSS)**
  - Today's space vehicle propulsion systems are very complex
  - Lack of major vehicle functional integration creates duplication of system major components (fluid tanks, pressurization systems, etc)
  - Too many interfaces (flight to flight & flight to ground)
  - Directly influences complexity of ground launch infrastructure and total flight/ground systems support logistics (includes hardware and commodity logistics suppliers)
  - Design done without using an integrated approach for total vehicle
    - Stove pipe approach – optimized each subsystem as a stand-a-lone
  - Too costly to operate and not efficient (**NOT AFFORDABLE and SUSTAINABLE**)

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OEPSS identified operations concerns and impacts (Causes and Effects)

No.	
1	Closed aft compartments
1A	Fluid system leakage
2	Hydraulics system (valve actuators and TVC)
3	Ocean recovery/refurbishment
4	Multiple propellants
5	Hypergolic propellants (safety)
6	Accessibility
7	Sophisticated heat shielding
8	Excessive components/subsystems
9	Lack of hardware integration
10	Separate OMS/RCS
11	Pneumatic system (valve actuators)
12	Gimbal system
13	High maintenance turbopumps

No.	
14	Ordnance operations
15	Retractable T-0 umbilical carrier plates
16	Pressurization system
17	Inert gas purge
18	Excessive interfaces
19	Helium spin start
20	Conditioning/geysering (LO2 tank forward)
21	Preconditioning system
22	Expensive helium usage – helium
23	Lack of hardware commonality
24	Propellant contamination
25	Side-mounted booster vehicles (multiple stage propulsion systems)
26	Component internal leakage

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- OEPSS provided data (volume1) related to these inefficiencies documenting the manpower and time to process these systems
- OEPSS provided definition of the listed 26 concerns (volume 2)
- OEPSS defined suggested operations technologies that could improve ground processing these propulsion systems
- OEPSS defined design concepts for new vehicle propulsion systems (volume 4) New technologies and concepts must be included during the design concept phase for any new vehicle.
- The above 4 volumes were completed during the first phase of the OEPSS and there are several additional volumes available including a complete video for your benefit of understanding

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- Recommendations:
  - To achieve operationally efficient propulsion systems for future space launch vehicles (Space Transportation Systems), the designer/developer needs to understand the lessons learned from the present Space Shuttle propulsion systems so that the operational considerations drive the design concept through development for greater simplicity and operability.
  - Reviewing OEPSS and the many follow-on studies by the Space Propulsion Synergy Team (SPST) is an excellent way for designers to obtain the needed understanding to produce an affordable/sustainable Space Transportation System of the future
    - These new designs need to be designed as an integrated entity that is inclusive of all the propulsion functions including the ground to be considered as a total system, e.g., final optimization must be from an integrated system perspective with affordability/sustainability as the primary driver and not simply the traditional performance with all other attributes as figure of merit considerations.

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OEPSS GENERIC CORE VEHICLE
Engine Systems Processing Duration and Manpower

Oper.	OMI	Activity	Dur. Hrs.	Head Count	Manhours
0R002	-	Vehicle at Processing Facility	-	-	
0R201	V5003	Tail cone removal POSU	34	20	680
0R211	V5003	Tail cone removal	8	19	152
0R214A	V5043	Remove SSME heat shields & carriers POSU	9	12	108
0R214	V5043	Remove SSME heat shields & carriers	103	12	1236
0R737	V1011.01	SSME engine drying POSU	20	3	60
0R041/0.41A	V1011.01	SSME engine drying	24	7	168
0R738	V1011.01	SSME engine drying P0I	5	3	15
0R519	V5058	SSME engine removal POSU	64	14	896
0R596	V5058	Remove SSME 1/2/3	32	14	448
0R018A	V3508	Close aft swing platforms	9	3	27
0R018	V3508	Close aft swing platforms	9	3	27
0R592	V3508	Configure swings	4	3	12
0R431	-	SSME offline opers.	672	*18.7	12544
0R559	V5005	Install SSME1	12	15	180
0R560	V5005	Install SSME2	12	15	180
0R561	V5005	Install SSME3	12	15	180
0R571	V1011.04	Hex leak checks	50	3	150
0R091	V1011.05	HGM/LOX/LH2 L&F	54	4	216
0R104	V1011.06	SSME FRT	12	6	72
0R105	V5043	Install heat shields and carriers	72	10	720
0R552	V1009.03	HE sys flt pres ISO test POSU	16	8	128
0R553	V1009.03	HE sys flt pres ISO test	24	8	192
		TOTAL	1215		17,589

* Rocketdyne manpower for SSME offline O&M

	Techs	Quality	Engrs.	
1st Shift	8	3	12	
2nd Shift	8	3	2	
3rd Shift	6	2	1	
Shop support	6	3	2	
	28	11	17	TOTAL - 56 Heads

Rockwell International
Rocketdyne Division

672 Hrs. is 28 days of 3-shift operations for an average headcount of 18.7 at all times.

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OEPSS GENERIC CORE VEHICLE
Hydraulics and APU Processing Duration and Manpower

Oper.	OMI	Activity	Dur. Hrs.	Head Count	Manhours
0R002	-	Vehicle at Processing Facility	-	-	
0R717	V5U02/V1153	APU H20 VLVS R&R/Deservice POSU	32	5	160
0R718	V5U02/V1153	APU H20 Deservice/Service	80	8	640
0R719	V1153	APU H20 Service secure	4	4	16
0R611	V1078	APU lube oil service POSU	8	5	40
0R071	V1078	APU lube oil service	26	10	260
0R733	V1078	APU lube oil service POI	8	4	32
0R600	V1010	Hyd. sys. fill & bleed POSU	24	5	120
0R452	V9002	Hyd. tray/hose configure	10	11	110
0R068	V9002.07	Hyd Power-up POSU	17	3	51
0RAA4	V9002.1	Hyd. Power-up/down	2	11	22
0R525	V1010	Hyd.sys. fill & bleed	32	14	448
0R053	V6012	Hyd. sys. inspect	64	4	256
0R083 A-D	V1196/1158	APU catch bottle drain	96	23	2208
0R572&A	V1078	APU lube/oil deservice POSU (STSX .67)*	64	10	640
0R573	V1078	APU lube/oil deservice	9	10	90
0R532	V1235	APU fuel vlv. resistance test	40	5	200
0R533	V1019	APU leak & functional POSU	16	10	160
0R741	V1019	APU leak & functional	176	10	1760
0R741A	V1019	APU leak & functional POI	48	8	384
		TOTAL	756		7597

* Contains POSU for 3 procedures; one of which is for OMS/RCS hypergols not used by generic core.

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Rocketdyne Division

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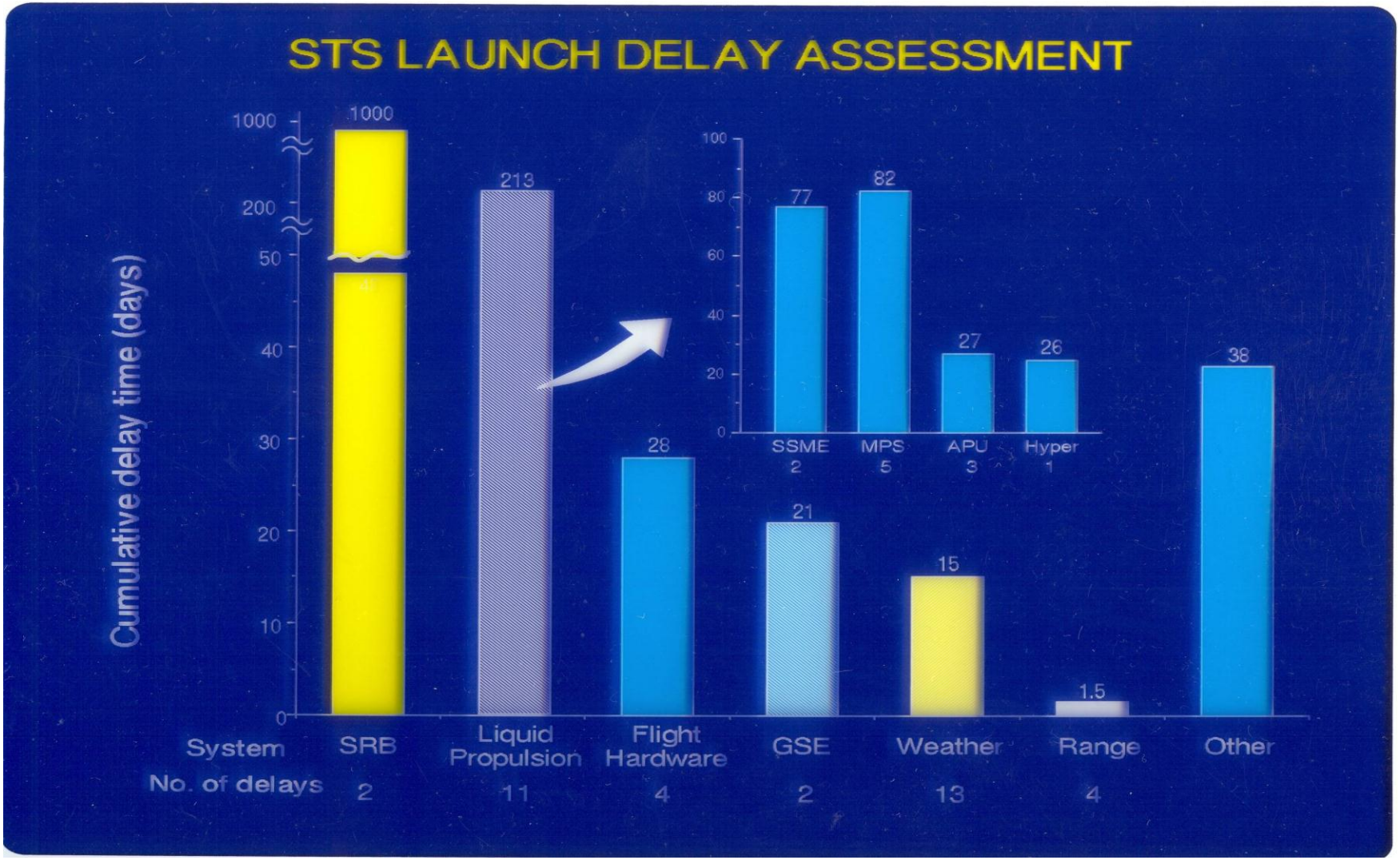

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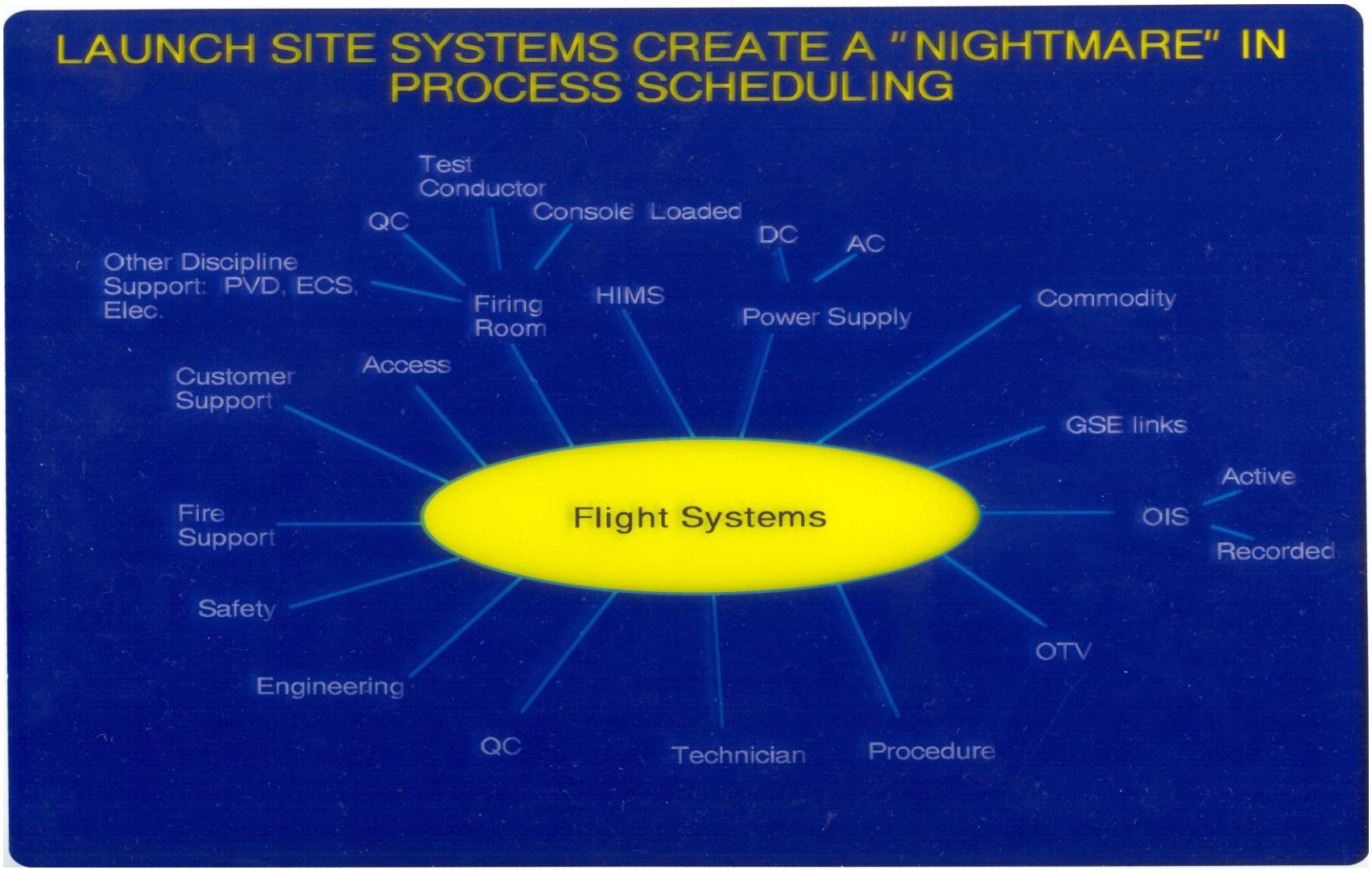

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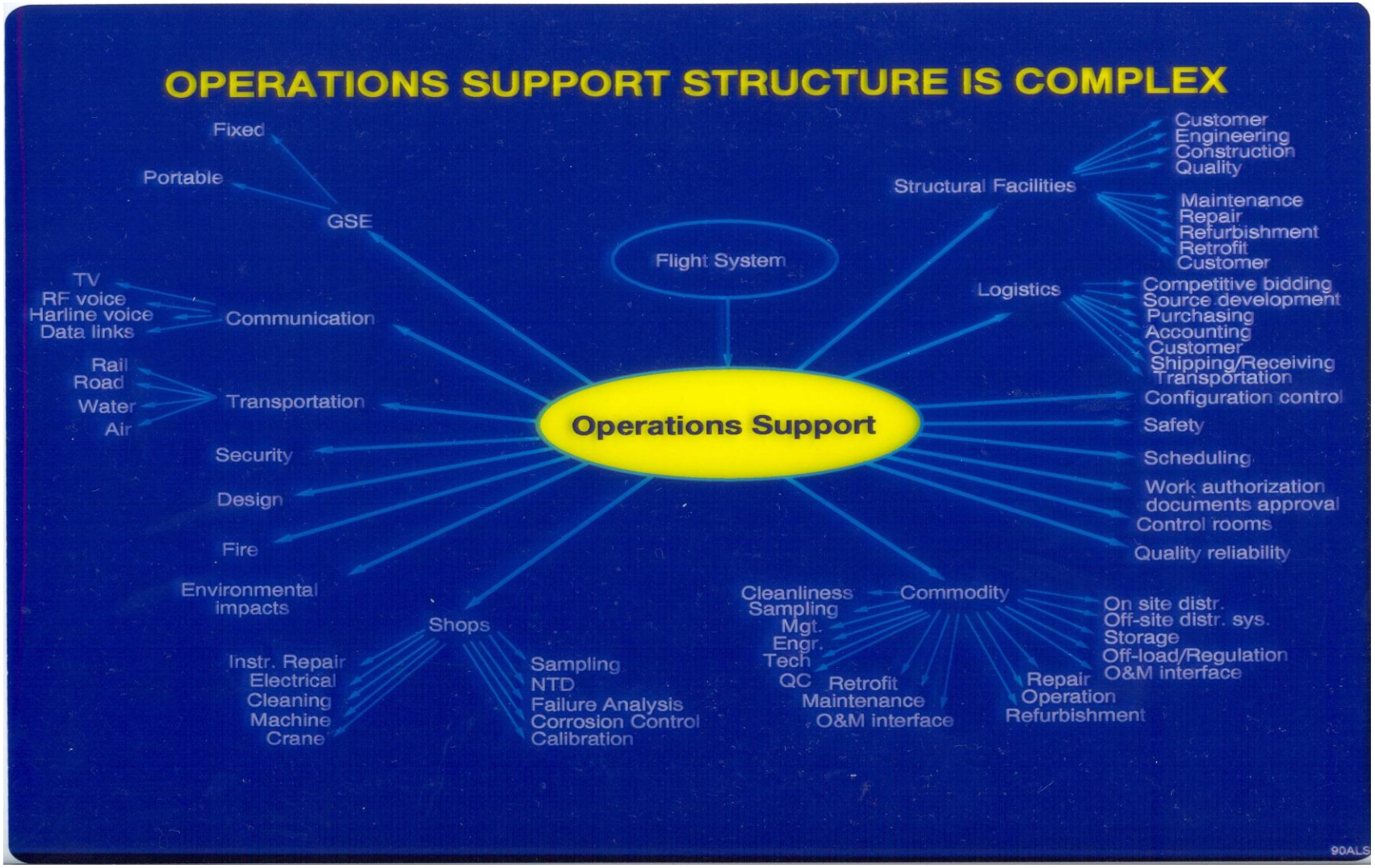
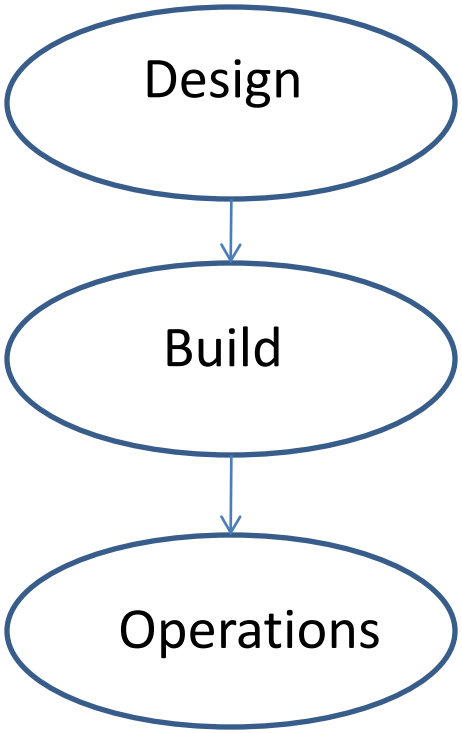
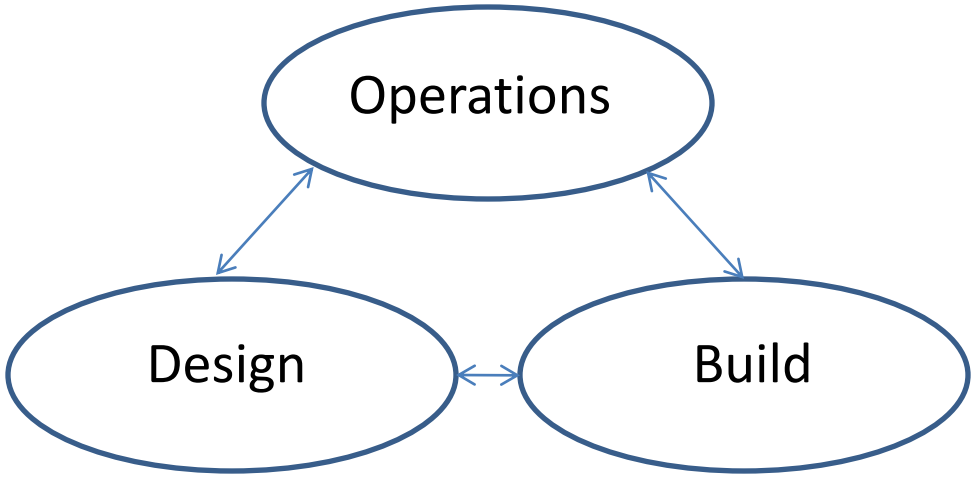


OPERATIONS AND DESIGN MUST BE INTERACTIVE



Traditional



OEPSS

Total Quality Management (TQM)

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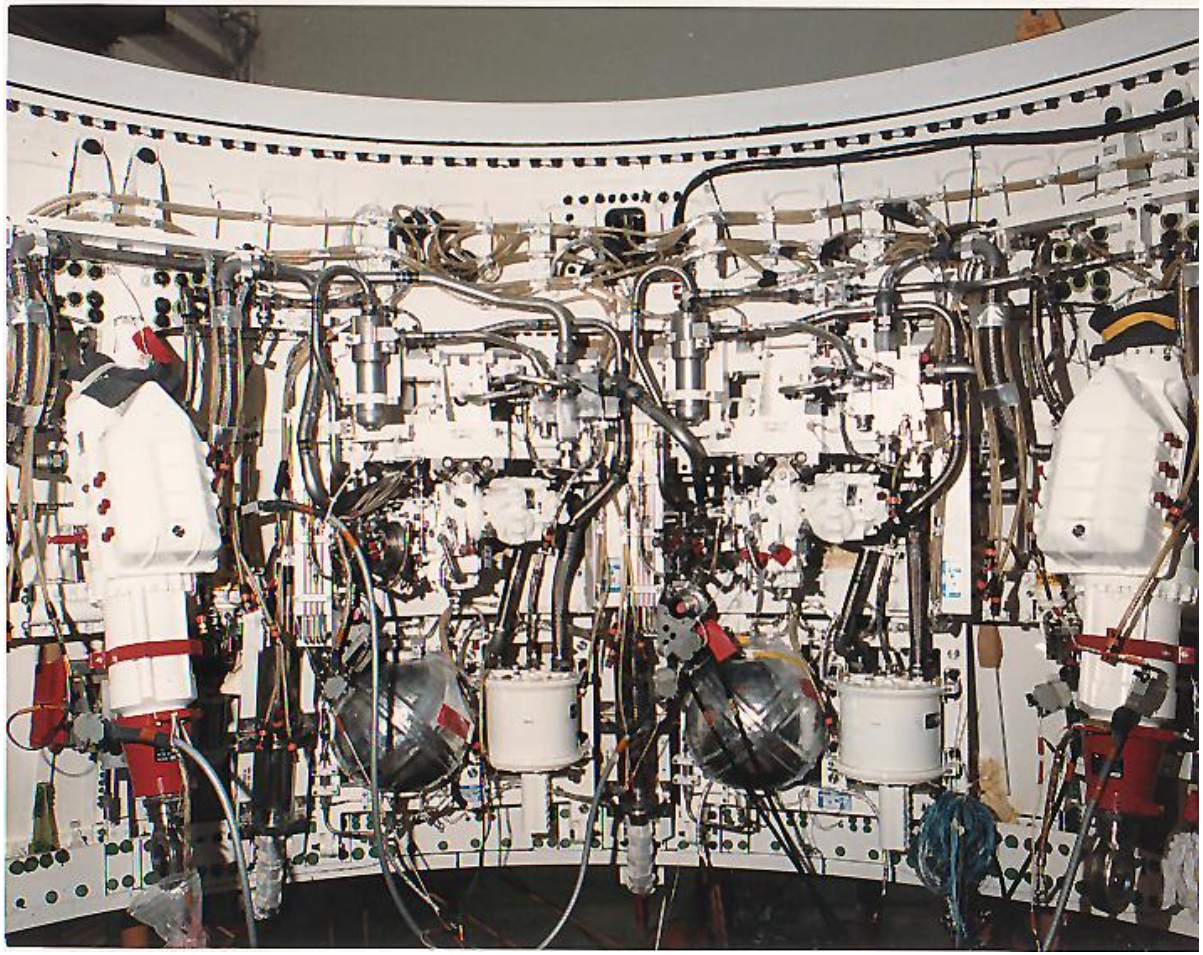

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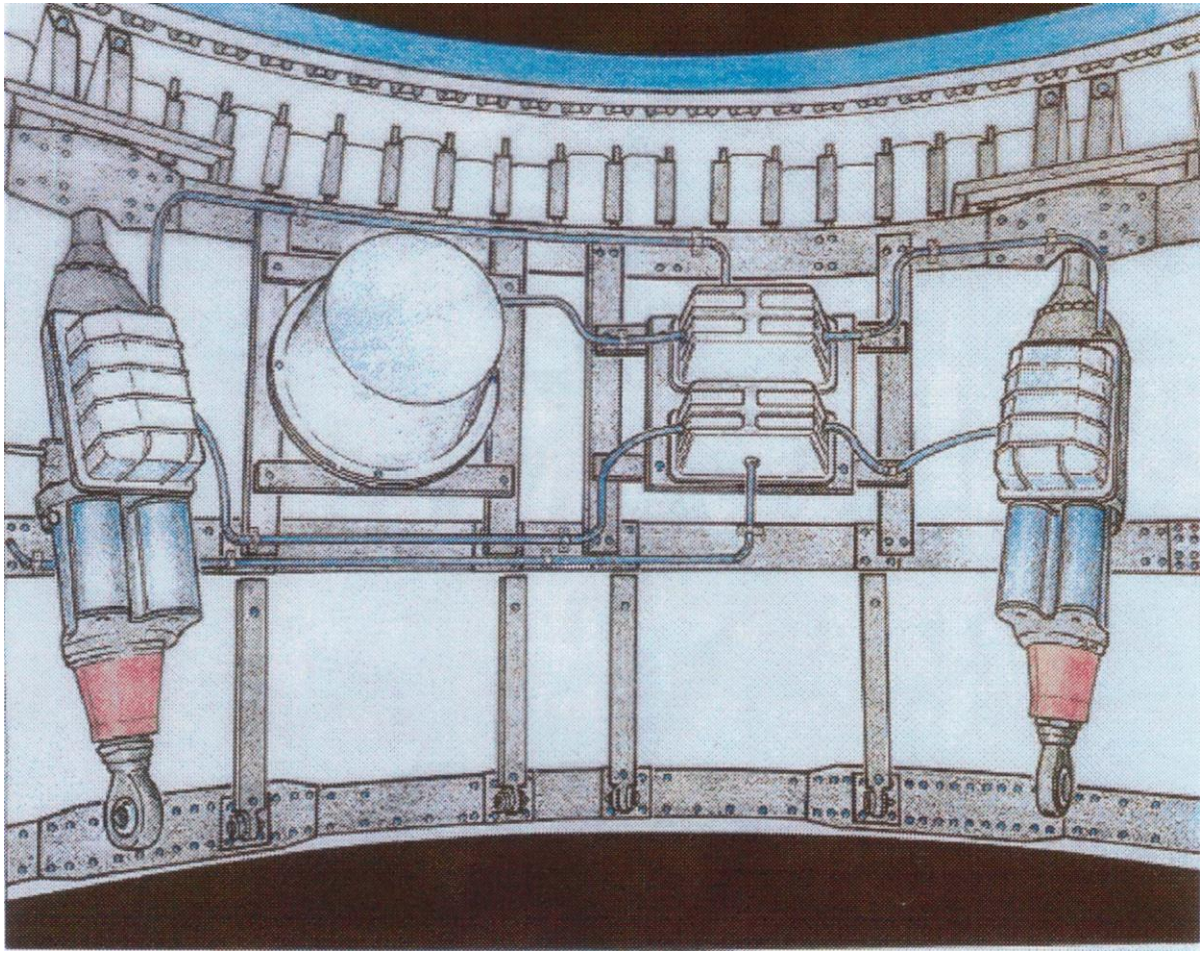

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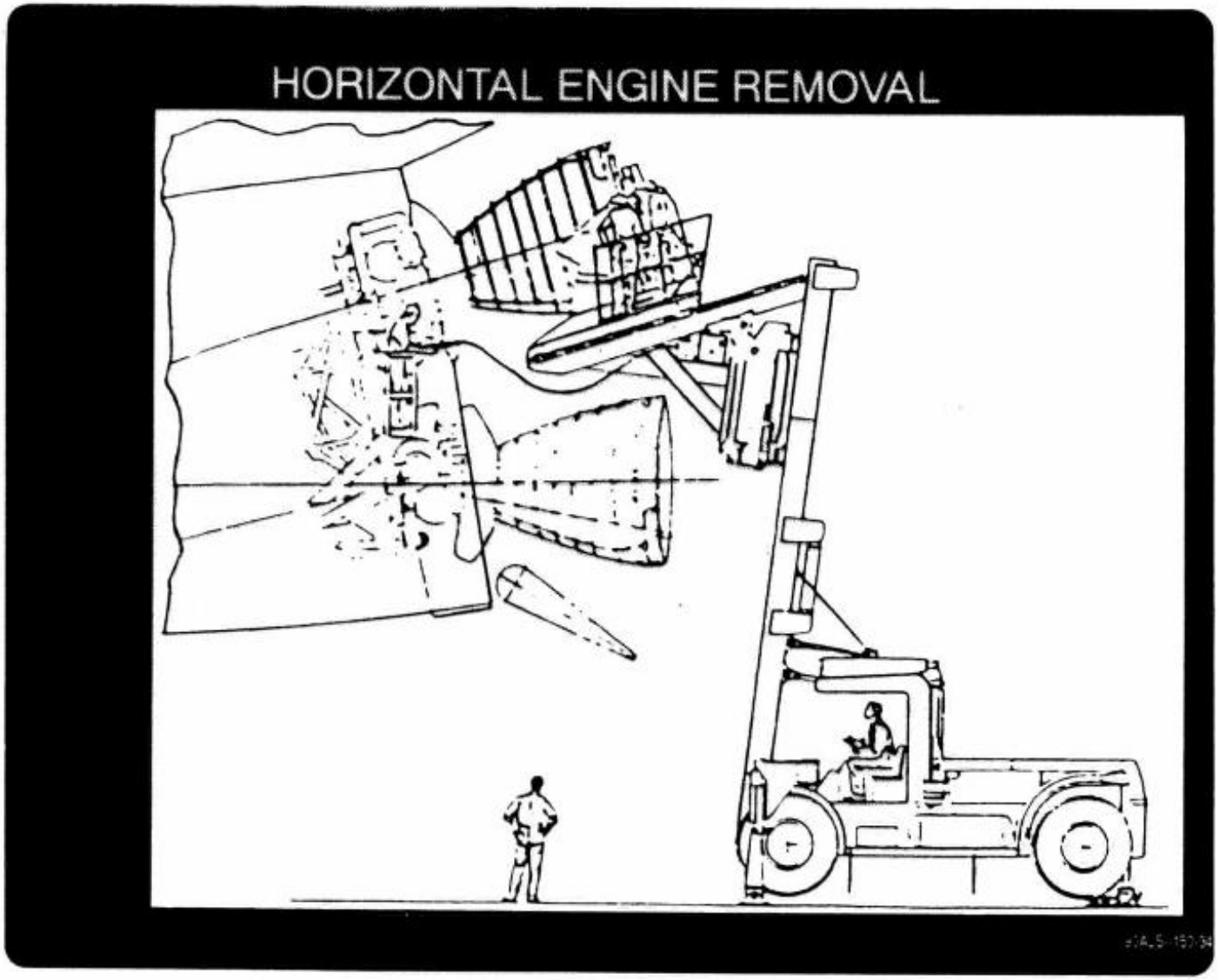

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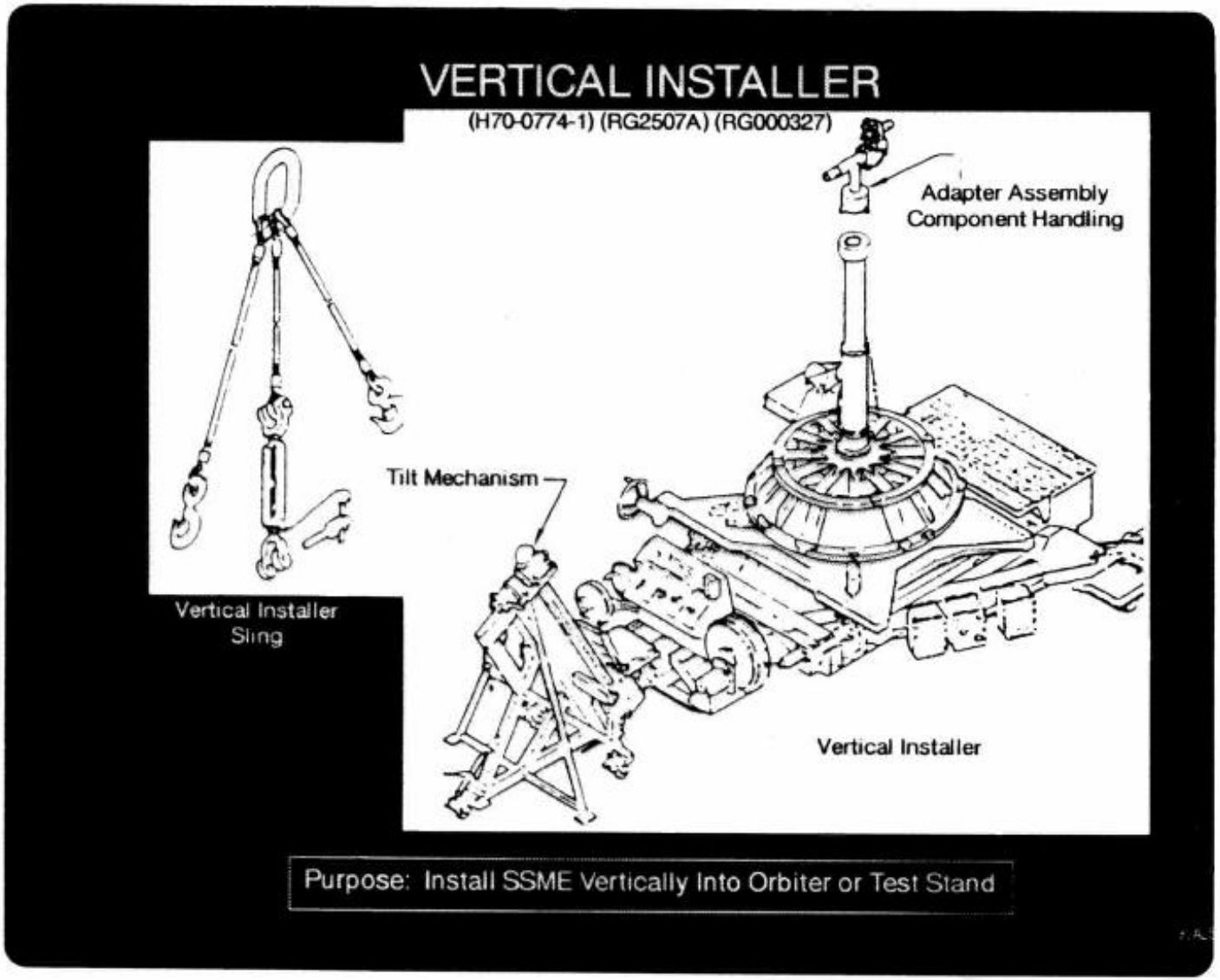

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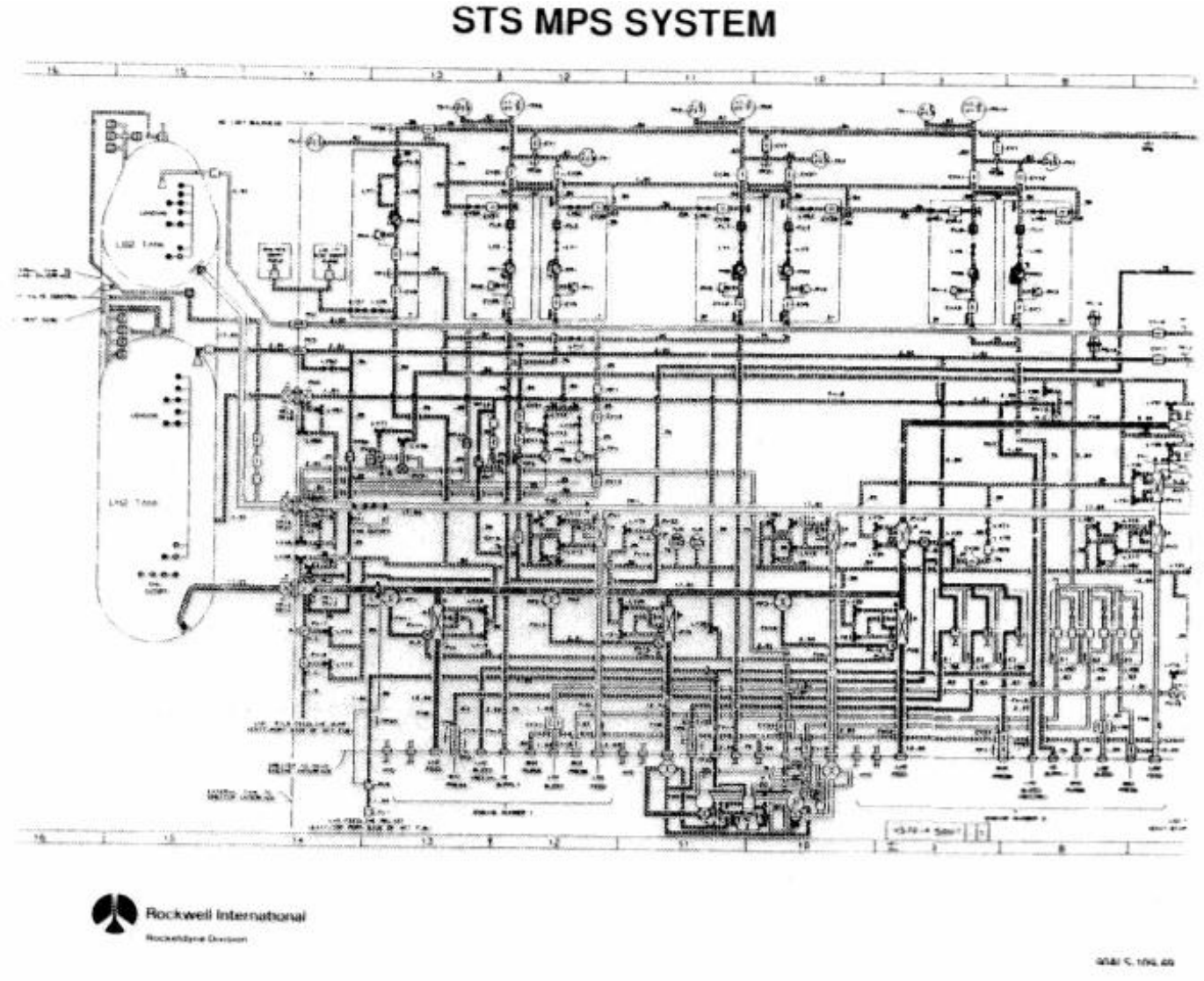

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